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著者	Takahashi Y., Orihara H., Ieki K., Hoshino T., Ohnuma H.
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Takahashi Y., Orihara H.*, Ieki K.**, Hoshino T.** and Ohnuma H.**
Department of Physics, Faculty of Science, Tohoku University
Cyclotron and Radioisotope Center, Tohoku University*
Department of Physics, Tokyo Institute of Technology**

It has been highly interesting to investigate spin-isospin excitation in nuclei caused by the $(\sigma\sigma)$ $(\tau\tau)$ $V_{\sigma\tau}$ channel in the effective nucleon-nucleon interactions by means of, for example, the charge-exchange (p,n) reaction. Except some cases by Taddeucci and his collaborators[1)], studies for this reaction have been, so far, limited on cross-section measurement due to the difficulties to obtain polarized proton beams and/or to measure the neutron polarization. In a research program to study spin-observables[2)], we have constructed a liquid-helium scintillation detector, which is suitable for the measurements of polarization for low-energy neutrons, in $E_n \leq 50$ MeV, with its sufficient analysing power and its large enough cross sections to scatter neutrons[3)], though there needed some special instrumentations to handle with liquid helium. In addition, in case we succeed to extract light-events from neutron impact on helium, this information, as a timing signal, can be used for the considerable improvement of the S/N ratios. Polarization of emitted neutrons is expressed in terms of R, ratio for the number of neutrons scattered towards left side to that of neutrons towards right side, and A, analysing power of polarimeter (He), as

$$P = \frac{1}{A} \cdot \frac{R-1}{R+1} \qquad (1),$$

thus larger A yields larger R, giving us precise data on P. Polarization values are deduced by the effective analysing power $\langle A \rangle$ estimated by a simulation code, where multiple scattering of neutrons by helium, the finite size effects of the detector, etc. are taken into accounts.

A test experiment was performed with use of a 18-MeV deuteron beam from the AVF cyclotron and the time-of-flight facilities at CYRIC.[4)] A gascel, filled with 4 atm. D_2 gas, was used as the neutron production target. Figure 1 shows the layout of the polarization measurement apparatus. By beam swinger of the TOF system, incident deuterons are rotated in a vertical plane, hence the asymmetry to be measured in eq. (1) appears in the vertical plane, as well. Neutron detectors are located at $\theta_L = \pm 135°$ with respect to the neutron direction at a distance of 30 cm from the center of the helium scatterer. A pair of liquid scintillator NE213 (1.6ℓ) with 5"$\phi\times$5" thick dimensions were used. Schematic view of the liquid helium polarimeter is shown in Fig. 2, where the helium container has dimensions of 77$\phi \times$ 74 mm thick. Light events in helium viewed by a photomultiplier through a silica window.

Figure 3 shows TOF spectra of neutrons detected at both side with respect to the emitted directions, left side (top) and right side (bottom). These TOF events are gated by light, n-γ discrimination, and "sub-TOF" signals collected by two-neutron detectors. (Note that TOF means the neutron flight time between the "target" and the helium detector, while sub-TOF means that between the helium detector and one of neutron detectors.) It is obvious that the neutrons yield leading to the ground state of ^{3}He is larger at upper side than that at lower side, giving us the measure of an asymmetry. We can obtain the polarization of emitted neutrons by the aids of eq. (1) and the effective analysing power $\langle A \rangle$. The polarizations, thus obtained, are displayed in Fig. 4 as a function of the emitted angle for neutrons from the $D(d,\vec{n})^3He(g.s.)$ reaction. The previous result by Hardekopf et al.[5] is also shown for comparison.

We have constructed a liquid helium polarimeter to measure the emitted neutron polarization. Light events from helium scatterer were used to gate TOF spectrum, and gave, indeed, high quality data. Agreements in polarization measurement for $D(d,\vec{n})^3He$ reaction of the present results with those previously obtained are satisfactory.

References

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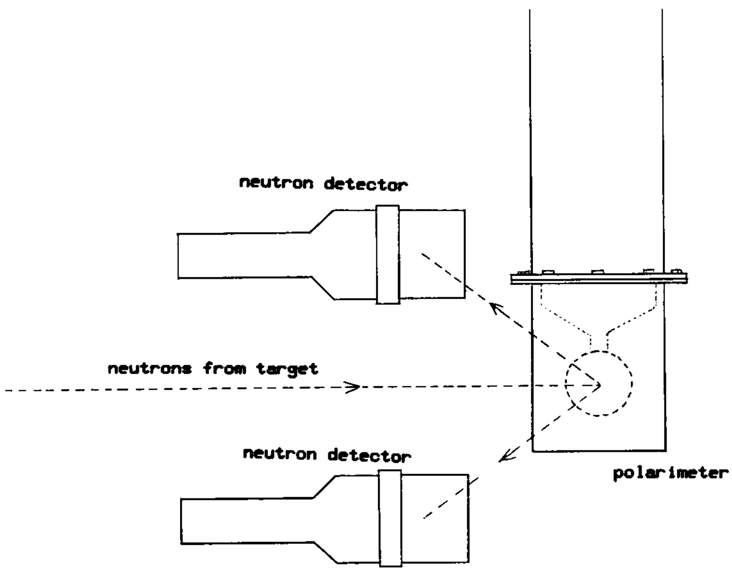

Fig. 1. Layout of the polarization measurement. Liquid scintillator NE213 is encapsulated in the 5"ϕ×5" container, and viewed by a 5"ϕ photomultiplier.

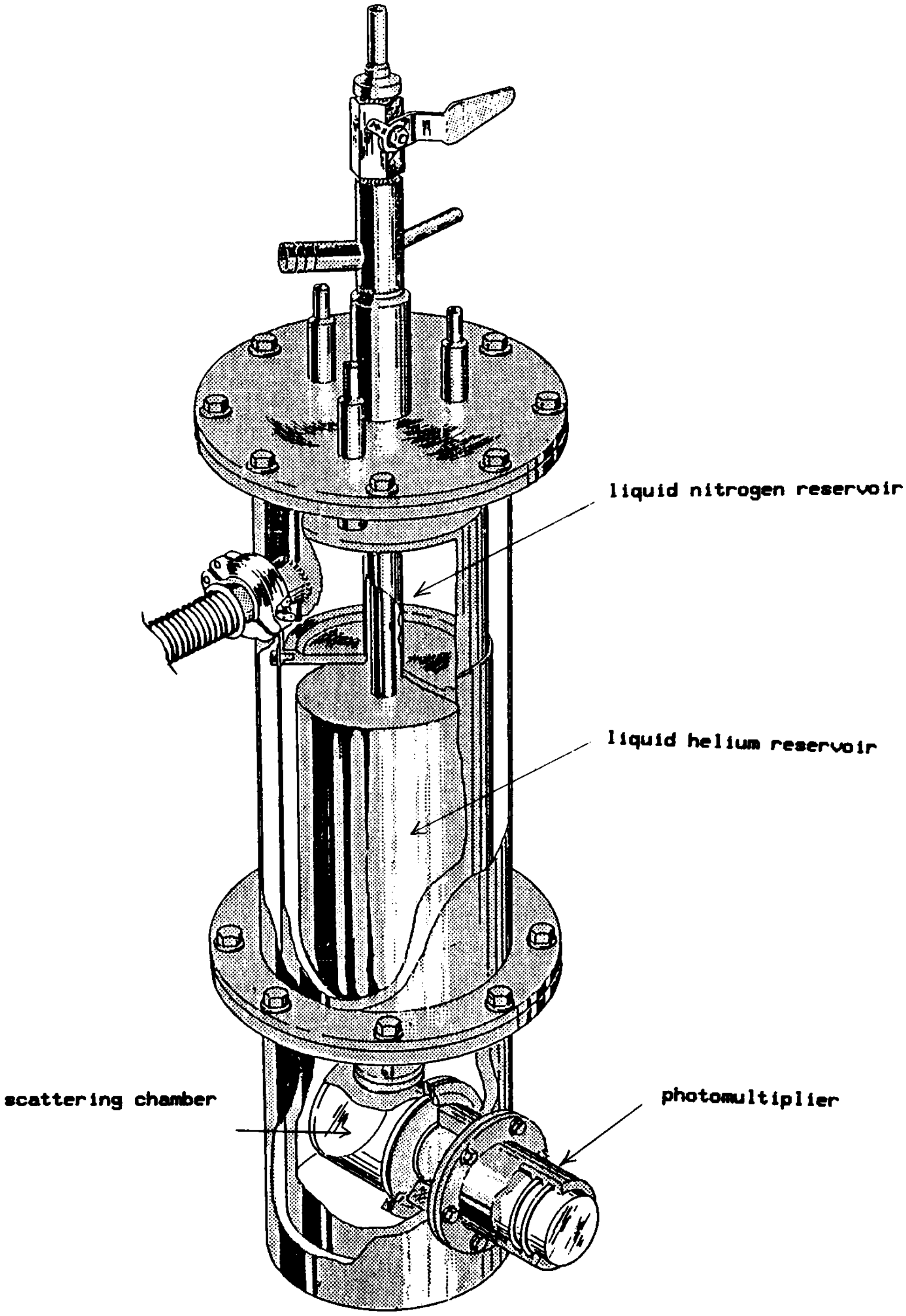

Fig. 2. Schematic view of the liquid helium polarimeter.

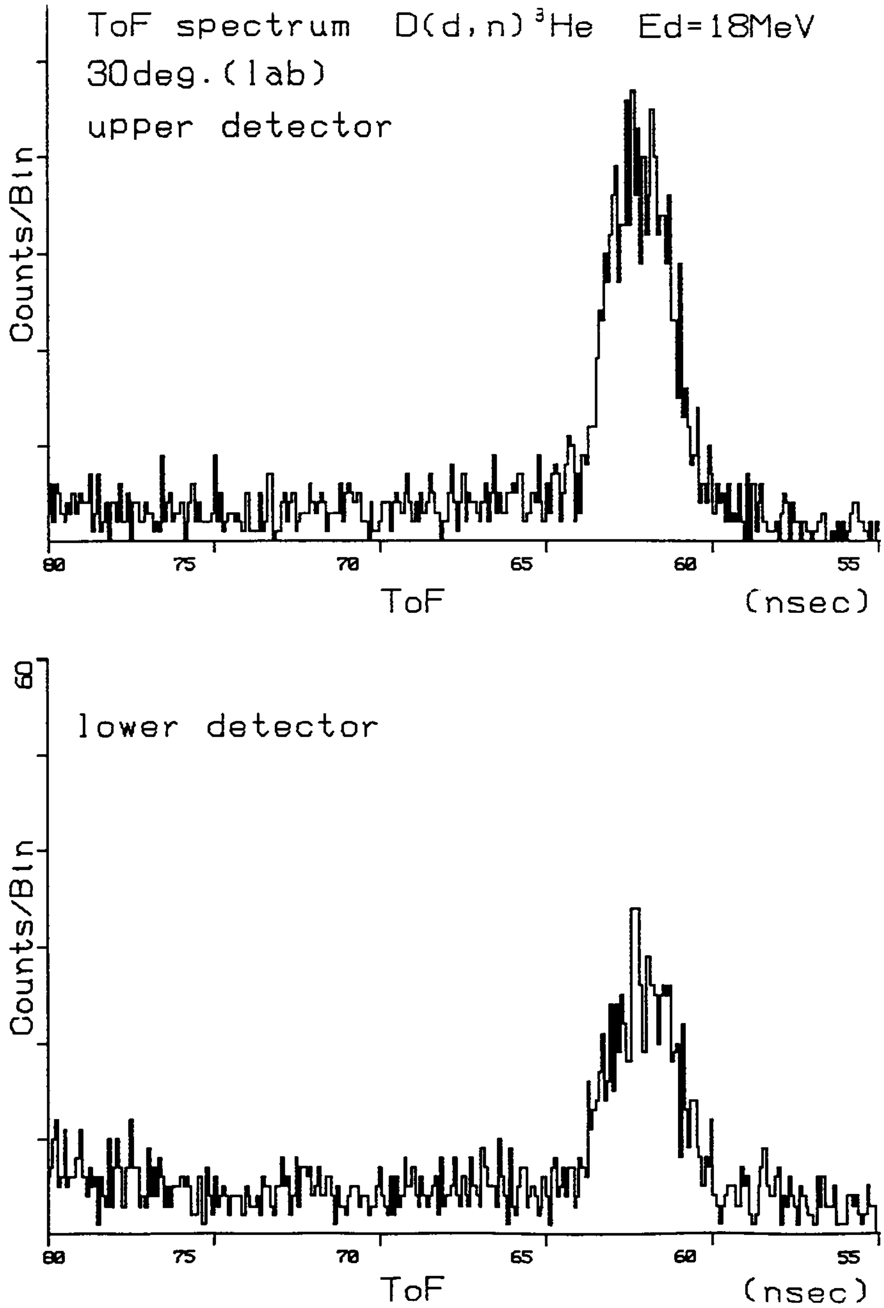

Fig. 3. TOF spectra of neutrons from the $D(d,n)^3He$(g.s.).

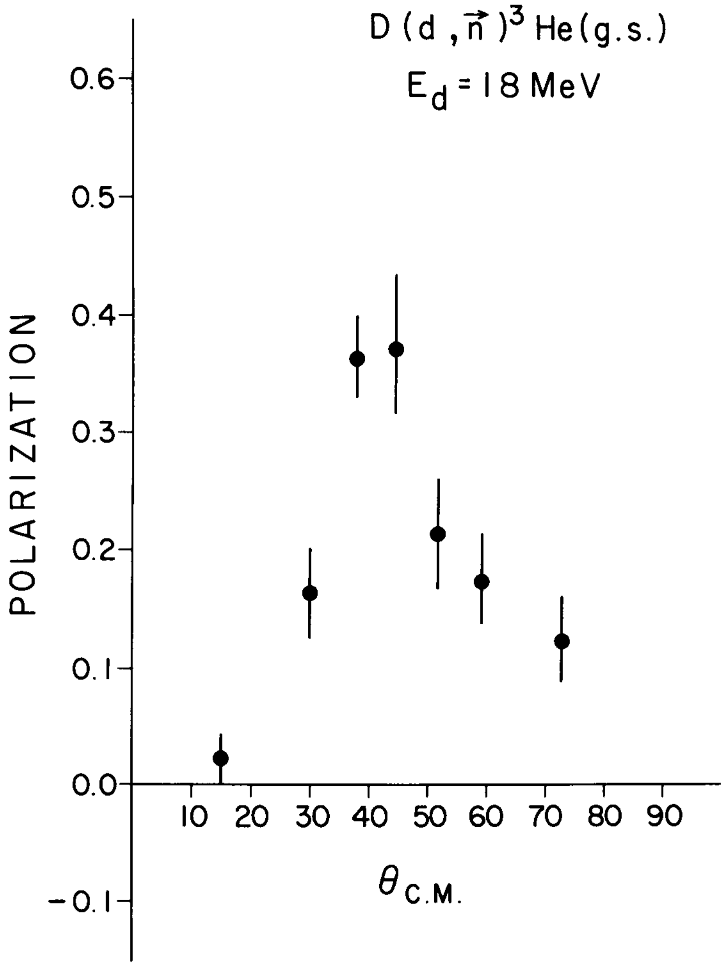

Fig. 4. Polarization of neutrons from the $^{2}H(d,n)^{3}He$ reaction at E_d = 18 MeV.